WHITE PAPER

Adaptive Management: Exploration of the Framework and its Potential Use in Hydraulic Project Approval Habitat Conservation Planning

Prepared by

Marc Daily
Washington Department of Fish and Wildlife
Habitat Program
Olympia, Washington

October 2006

Contents

List of Acronyms 2

1. Overview of Hydraulic Project Approval Habitat Conservation Planning Project 3

2. Overview of this Adaptive Management Paper 3

3. Methods.....4

4. Overview of the Adaptive Management Framework and its Application 5

5. Primary Components of Adaptive Management.....7

   Definition of Goals and Objectives. 7
   Model Creation and Definition of Management Alternatives. 9
   Define Indicators and Develop Monitoring Program. 12
   Framework for Evaluation of Monitoring Results and Adjustment of Management Strategies 17

6. Interested Party Involvement in Adaptive Management 18

7. Why Adaptive Management Has Not Reached Its Potential 20

8. Institutional Changes that could Improve Adaptive Management Implementation 22

9. Adaptive Management Use in Habitat Conservation Planning 23

10. Preliminary Ideas for Adaptive Management Use in the Hydraulic Project Approval Habitat Conservation Planning Process.....26

11. Bibliography 30

List of Acronyms

ESA	Endangered Species Act
HCP	Habitat Conservation Plan
HPA	Hydraulic Project Approval
ITP	Incidental Take Permit
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries Service
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

1. Overview of Hydraulic Project Approval Habitat Conservation Planning Project

In Washington State, activities that use, divert, obstruct, or change the bed[1] or flow of state waters require a Hydraulic Project Approval (HPA) from the Washington Department of Fish and Wildlife (WDFW). The purpose of the HPA program is to ensure that such activities are completed in a manner that prevents damage to public fish and shellfish resources and their habitats. Because several fish and aquatic species in the state are listed as threatened or endangered under the federal Endangered Species Act (ESA), many of the activities requiring an HPA may also require approvals from the National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS). Such approvals can be in the form of an ESA Section 7 Incidental Take Statement or an ESA Section 10 Incidental Take Permit (ITP). As authorized in Section 10 of the ESA, ITPs may be issued for otherwise lawful activities that could result in "take" of ESA-listed species or their habitats. In this context, take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct.

To ensure that the HPA program complies with the ESA and to facilitate ESA compliance for citizens conducting work under the HPA authority, the WDFW is working toward development of a programmatic, multispecies Habitat Conservation Plan (HCP) to obtain an ITP from USFWS and NOAA Fisheries (collectively referred to as the Services). Currently, WDFW is in the first year of what is expected to be a six-year project to develop an HCP. An HCP must outline conservation measures for avoiding, minimizing, and mitigating, to the maximum extent practicable, the impact of the permitted take on the potentially covered species.[2] The federal Services must also find in their biological opinion that any permitted incidental take will not jeopardize continued existence of the species, i.e., the taking will not appreciably reduce the likelihood of survival and recovery of the species in the wild.

2. Overview of this Adaptive Management Paper

The drafting and negotiation of an HCP under Section 10 of the ESA is a complex process. No matter how much planning and scientific research are conducted during development, it is inevitable that uncertainties will remain related to the nature of the activities covered and how they may relate to adverse impacts to sensitive species and their habitats. It is crucial that management of sensitive species and continued human development is not hampered by uncertainty. Instead, uncertainty must be addressed directly and management decisions must be made in spite of uncertainty. Adaptive management is a framework that first was applied to natural resource issues in the late 1970s as a structured method for addressing uncertainty.

[1] Bed is defined as the land below the ordinary high water line of the state waters, but does not include irrigation ditches, canals, stormwater runoff devices, or other artificial watercourses except where they exist in a natural watercourse that has been altered by humans.

[2] In this paper, "potentially covered species" refers to species that could be covered in the HCP; however, a final determination will be made at the time the HCP is finalized between WDFW and the federal Services.

Beginning in the early 1990s adaptive management grew in popularity and has been applied to all manners of natural resource management. In the management of sensitive species and their habitats, adaptive management became a key part of ESA planning with the issuance of the Habitat Conservation Planning Handbook (USFWS and NOAA Fisheries 1996) and was further addressed in the addendum to the 1996 handbook, commonly referred to as the five points policy (65 Federal Register 35242-35257). In all facets of natural resource management, and in the management of sensitive species in particular, the concept has shown promise, but oftentimes is not fully applied.

The following paper is not meant to formalize a specific adaptive management strategy for the HPA HCP, but is meant to explore the concept of adaptive management, how the Services envision use of adaptive management in ESA planning, and issues and lessons learned that WDFW should consider in the development of an adaptive management program for the HPA HCP. By examining adaptive management and components of a successful program early in HPA HCP development, the information can help guide the planning efforts, as WDFW gathers more information, creates models for assessment, formulates management directives, and develops methods for HCP implementation. This will allow adaptive management to drive the planning process rather than being an afterthought addressed near the end of HCP development.

3. Methods

The white paper is based upon a review of the pertinent literature related to the use of adaptive management for natural resources and in particular for ESA planning. Databases used in the literature search included the Washington State Library catalog, the Evergreen State College Library Catalog, University of Washington Library catalog, general internet searches using Google, the NOAA Fisheries Northwest Regional Office ESA consultation database, and the U.S. Fish and Wildlife Service Conservation Plans and Agreements database.

Information from these sources was reviewed for relevance and the key pieces of information were synthesized in the following paper. All reference materials associated with this work are part of the public record for the HPA HCP effort.

4. Overview of the Adaptive Management Framework and its Application

With the establishment of many new environmental regulations in the early 1970s there arose an increasing need for management approaches related to complex, dynamic, and oftentimes poorly understood natural processes and functions. In an effort to acknowledge and embrace the uncertainties associated with environmental systems, Holling (1978) first proposed the concept of Adaptive Environmental Assessment and Management (now commonly referred to as adaptive management). Over the past decade, use of the term adaptive management has become widespread and the concept has been reworked and redefined for use in many different natural resource arenas. However, due to the morphing of the original framework, many now have differing views of what adaptive management entails, what is required for it to be successful, and how it should be implemented (Failing 2004). In many cases, adaptive management is used as little more than a catch phrase that basically equates to a placeholder for postponing decision-making (Stankey et al. 2005).

The following overview discusses the major components common to most definitions of adaptive management and defines how adaptive management differs from traditional decision-making and management approaches.

Generally, natural resource managers and government agencies make management decisions using one of five approaches: political/social, conventional wisdom; best current data, passive adaptive management, and active adaptive management (Johnson 1999).

Under the political/social approach the primary driver of decisions is the anticipated public and political response. This approach often dictates a course of action to satisfy the interests of particular stakeholders or to promote a specific agenda. The criteria for making decisions under this management approach are highly subjective and usually not transparent.

The conventional wisdom approach is one of the most frequently used. Resource managers rely on historical experience from similar situations and make decisions based upon what has worked previously and what has not. This approach assumes that the environmental conditions for the current situation will respond in a similar way to what was experienced in the past. This decision-making approach does not consider the unique nature of a given situation, but can provide a historical record of why decisions are made in a certain way (e.g., 500 fish are planted this year because 500 were planted each of the past 10 years and it seems to have achieved our goals).

The best current data approach uses available data, reports, and other information to assess possible management options and then chooses a single management strategy to implement. This approach is far less subjective and can provide for a record of the information used and

rationale for the decision. However, this approach does not provide for assessment after the fact to evaluate whether the management strategy produced the desired result.

The next two approaches were borne out of the acknowledgement that uncertainty is an inseparable component of natural resource management. It became necessary to develop management frameworks that better account for uncertainty and use that uncertainty to more effectively manage (Vail and Skaggs 2002). But more than just dealing with uncertainty, adaptive management is designed to get away from traditional strategies which tend to view management and policy decisions as final, and only through obvious failure or conflict do decisions get revisited and revised (Vail and Skaggs 2002). Adaptive management has arisen as an alternative to the traditional approach to policy and management decision-making.

There are two primary forms of adaptive management: passive and active. Passive adaptive management begins with identifying the goals and objectives for management. Available information is reviewed, alternatives are developed, and then a single course of action considered to be the best is implemented. However, with passive adaptive management, this is not the end of the process. The outcomes of the management actions are monitored based upon pre-defined indicators, the results of the monitoring are periodically reviewed, and the management decisions are adjusted, if needed, based upon the results of the monitoring (Stankey et al. 2005, Johnson 1999).

Active adaptive management is similar, but is treated more as an experiment. A range of alternative management strategies is defined and implemented rather than focusing on a single, presumed best, action. All of the alternatives are evaluated, usually using computer modeling, and implemented either concurrently or sequentially based upon a pre-defined process, monitored, and evaluated for necessary changes (Failing et al. 2004, PAMRS 2004). Through implementing and evaluating multiple alternatives, decision-makers can hone in on a true optimal management strategy, whereas more linear decision-making may find a serviceable alternative, but fall short of identifying the best strategy for meeting the goals and objectives. Under active adaptive management, formal adoption of a management strategy occurs only after monitoring results have confirmed which management strategy produces the most desirable results (Stankey et al. 2005, Johnson 1999).

What distinguishes adaptive management (either passive or active) from more traditional trial and error approaches is its purposefulness (Stankey et al. 2005). It applies scientific rationality to the problem of uncertainty. It uses an experimental approach to the design and implementation of natural resource policies. Thereby, management is couched as an ongoing study in which policy alternatives are more like hypotheses rather than concrete decisions, which facilitates continuous learning about the environment being managed (Miller 1999). As Gunderson (1999) phrased it - with adaptive management, “policies are really questions masquerading as answers.” Over time, as more is learned about the environmental system being managed, policies and strategies can be altered to improve management success and to be more responsive to future conditions (Johnson 1999). This continuous learning process through experimentation and probing of the environment has led many authors to distill the definition of adaptive management down to simply “learning by doing” (Walters 1997, Stankey et al. 2005).

Adaptive management does not eliminate the need for decision-makers to use conventional wisdom and even political/social decision-making approaches at times, but it provides a structured approach to making such decisions and learning from the results (PAMRS 2004). Because a key tenet of adaptive management is allowing scientific information and experimentation to guide management decisions, it is relatively objective and provides defensibility and credibility that more subjective, less systematic management approaches cannot (Vail and Skaggs 2002).

Failing et al. (2004) notes that adaptive management is attractive to many decision makers because its fundamental principles are simple – "we don't know the answer, we don't want to guess, let's try it, watch what happens, and then we'll know for sure, or at least much better." However, implementation of adaptive management requires a shift in the traditional management paradigm of seeing the initial implementation of a management strategy as the end point. Adaptive management requires ongoing effort, funds, and staffing to support monitoring and related science programs, evaluation of strategies, and management adjustment (PAMRS 2004).

5. Primary Components of Adaptive Management

The characteristics of adaptive management described above are generally agreed upon, yet there are many nuances to the definitions that can lead to different interpretation. Yet, there are components that appear to be common to virtually all adaptive management definitions which include:

1) The development of measurable management goals and objectives;
2) Formulation of a suite of management alternatives through the definition of assumptions and synthesizing of existing information;
3) Selection of indicators that can be measured to demonstrate effectiveness of the management approach and development of a monitoring program to track indicator response to the management strategy; and
4) Creation of a framework to evaluate monitoring results and adjust the management strategy to improve effectiveness (Holling 1978, Nelson 2000, Gray 2000).

The following discusses these four primary components.

Definition of Goals and Objectives.

Before an adaptive management program can be implemented, it must be carefully defined and structured through the development of goals and objectives. The first step in this process is to fully flesh out the problem, which in the case of adaptive management means defining the uncertainties that the program will address. Through careful identification of the uncertainties, a logical incremental framework can be established to identify what the goals are for dealing

with or reducing the uncertainty, and defining what measurable objectives can be used to demonstrate the effectiveness of the management strategies (Stankey et al. 2005). This first step is fundamental to the process. Only through explicitly stating the uncertainties, goals, and objectives, can a systematic and defensible adaptive management program be created.

The determination of goals and objectives for natural resource management issues usually includes many differing interests and the decision-maker is oftentimes responsible for developing management strategies that best meet stakeholders' interests. Too frequently decision-makers assume that they intuitively understand the interests of stakeholders and they make management decisions based upon their perceptions. This leads to situations where differences in stakeholders' interests go unnoticed which can result in future conflict that may have been avoidable (Rogers 1998). With goals and objectives stated from the start, all stakeholders can have an opportunity to first, assess whether they agree with the defined goals and objectives and secondly, they can recognize what is considered success (Salafsky et al. 2001).

Ideally, goals and objectives would be established in collaboration with stakeholders so that all interests have an opportunity to help shape what is considered a successful management outcome. Yet in many situations, it may not be feasible to develop goals and objectives alongside stakeholders. It is important to recognize that adaptive management is not a tool for helping to define goals and objectives. Instead, it can only be effectively used once goals and objectives have been clearly defined and agreed to by the stakeholders (Salafsky et al. 2001, PAMRS 2004). Conflict over what the adaptive management program is meant to achieve can doom the effort before it begins (PAMRS 2004).

One method that authors note that can aid in minimizing conflict and maximizing the defensibility of the goals and the objectives from the beginning, is to ensure that decision-makers, planners, and scientists are all involved in the definition of the goals. Too often, these initial steps of defining goals of a program are viewed as strictly planning tasks and scientists are not included in the discussions (Rogers 1998). One of the primary benefits of adaptive management is its basis on scientific information and its objectivity. To fully capitalize on this benefit, institutions must ensure the scientists are involved in the formulation of an adaptive management program from start to finish, including the definition of goals and objectives (Failing et al. 2004). Including scientists, planners, and decision-makers in the definition of goals and objectives could make the process a bit more cumbersome and time-consuming, but it will help to avoid future conflict over the purpose of the adaptive management program and what defines success. Moreover, as scientists are crucial to the implementation of future steps in adaptive management (e.g., monitoring and evaluation) collaborating with them from the start can make the scientific research better directed to support management needs and make it easier for planners and decision-makers to utilize the scientific findings. This can help to further reduce uncertainty and improve the effectiveness of the adaptive management program (Zabel et al. 2002).

Model Creation and Definition of Management Alternatives.

Following the definition of goals and objectives, the next step is to formulate alternative management strategies geared toward achieving the goals and meeting the objectives. In adaptive management, this too must be done using a systematic, transparent approach so that all entities can evaluate the appropriateness of the alternatives. It is important to first outline the assumptions of how the system works and how it responds to stressors. It is a given that there is uncertainty, as this is the reason that adaptive management is being implemented in the first place. Yet in virtually all cases, there is some understanding or assumptions of how the environmental systems in question function and how they should respond to certain management strategies.

In adaptive management, the most accepted methodology for detailing these assumptions is to create a model of the environmental system to be managed. This idea of modeling is where the literature on adaptive management tends to vary the most. Modeling can be as simple as a matrix or conceptual diagram of how the system functions and what is expected to occur with different management strategies. These types of conceptual models are very effective at defining the assumptions in an easily digestible manner that can generally be understood by technical and non-technical entities. Again, this type of model is effective for capturing assumptions on how a system works, but they are limited in their predictive abilities related to the response of environmental systems.

The majority of the technical adaptive management texts promote the use of more complex mathematical and spatial computer models, which integrate existing experience and scientific information into dynamic models that attempt to project future conditions resulting from alternative management strategies (Walters 1997). Computer models are especially useful because they can incorporate and evaluate large data sets from multiple sources, and can quickly perform complex calculations to simulate real world conditions (Johnson 1999).

However, one of the problems with the use of computer models is that people can oftentimes begin to mistake model outputs for truth. No matter how complex and how seemingly accurate a model appears to be, it is still a fictitious representation of reality and can never eliminate uncertainty from management decisions (Walters 1997). Therefore, it is critical that a model be explicit in its limitations, recognizing data gaps and potential flaws due to simplifying assumptions (Stankey 2005, PAMRS 2004). When reality fails to agree with the model predictions, understanding can only be improved through careful documentation and review of model assumptions (Salafsky et al. 2001).

This modeling step, regardless of the complexity of the model developed, serves four functions – Models:

1) Help to further clarify the problem;
2) Provide a structured framework for organizing information and outlining assumptions;
3) Provide management strategy screening to eliminate options that are not likely to achieve the goals, and

4) Aid in identifying knowledge gaps that increase uncertainty and limit the ability to predict the results of differing management alternatives (Walters 1997, Zabel et al. 2002).

In short, the building of a model in adaptive management helps to replace the traditional trial-and-error decision-making approach with a more systematic process of defining assumptions and testing the efficacy of varying management strategies (Walters 1997).

Models are also crucial for capturing institutional knowledge. Adaptive management usually takes place over decades. The personnel involved in initiating an adaptive management program may not be the same people that evaluate results and make changes over time (Salafsky et al. 2001). A conceptual or computer model can provide detailed descriptions of the understanding of the time, assumptions, and data gaps. These pieces of information will be critical to evaluating results and adapting management strategies over time.

However, since models will never be able to eliminate uncertainty, as stated above, they should be designed as simply as possible to get the desired information (Walters 1997). In developing a model there is a tendency to add more and more variables and complexities. Yet, instead of improving the validity of a model, this can add confounding variables and obscure trends. Before any variable or data is added to a model, it must be asked, "what will this added detail tell us and is it absolutely necessary to include this data to obtain the answer?" If the answer to that question is no, then it should be questioned as to whether the variable or data should be added.

It is important to not get mired by trying to build a perfect model – it does not exist. Part of the implementation of adaptive management can be geared toward refining the model, just as assumptions will be refined. It is important to view the model as dynamic. Just like the management strategies to be implemented, the model must be open to change. Too often the time and money spent in producing a model make people unwilling to accept its change. This tendency must be avoided to provide for continued model relevance as understanding improves (Salafsky et al. 2001).

Through consideration of the goals and objectives and use of whatever type of model is developed, a range of management choices or alternatives must then be developed. It is important that during the formulation of alternatives that a wide range of strategies is considered (PAMRS 2004). In light of uncertainty, there is rarely, if ever, a single "best" management strategy. Evaluation of a wide range can help identify options that are most likely to achieve the desired outcome. Many factors may influence the type of alternatives to explore, including economics, policies and regulations, and the amount of risk to the environment (65 Federal Register 35242-35257).

Vail and Skaggs (2002) explain that alternatives must be robust. By robust they mean alternatives that strike a balance between caution to avoid adverse outcomes and experimenting to reduce uncertainty and maximize benefits. For example, an alternative may be expected to produce substantial benefits based upon a certain set of assumptions. However, if that

alternative could also result in little benefit or even adverse impacts based upon equally feasible assumptions, then the alternative is not very robust (Vail and Skaggs 2002).

After possible alternatives have been formulated, they are then run through the model that was created (be it a simple conceptual model or a computer model) to help determine which alternatives are most likely to achieve the desired results. Next, either the alternative that is considered best can be selected for implementation (passive adaptive management) or a suite of alternatives can be put forth for experimental implementation (active adaptive management).

To help in the selection of one or multiple alternatives, there are several factors that should be considered that the model should help to evaluate. The fundamental question for alternative selection is - what is the probability of successfully reducing uncertainty and achieving the desired result by implementing a given alternative and what are the relative costs of implementing the alternative? If a single alternative has a much higher probability of effectiveness, uncertainty reduction, and is economically feasible, then a passive adaptive management approach would likely be most effective and the added costs of an experimental, active adaptive management approach would not likely be appropriate. However, if multiple alternatives would equally reduce uncertainty, have similar probabilities of achieving the desired results, and are similar in cost, then an experimental or active adaptive management approach may be prudent to help identify the optimal alternative.

Yet, in implementing an active adaptive management approach it is necessary to evaluate the probability of gaining useful information through experimentation. In essence, the power of the experimental implementation methodology to accurately show differences in effectiveness of the various alternatives should be considered. Similarly, it is important to assess the likelihood that differences in alternatives and uncertainty reduction, if discovered through experimentation, would actually result in changes in management decisions.

To illustrate this point, Failing et al. 2004 presents a useful conceptual diagram for when experimental, active adaptive management or passive adaptive management is most likely to be prudent (Figure 1).

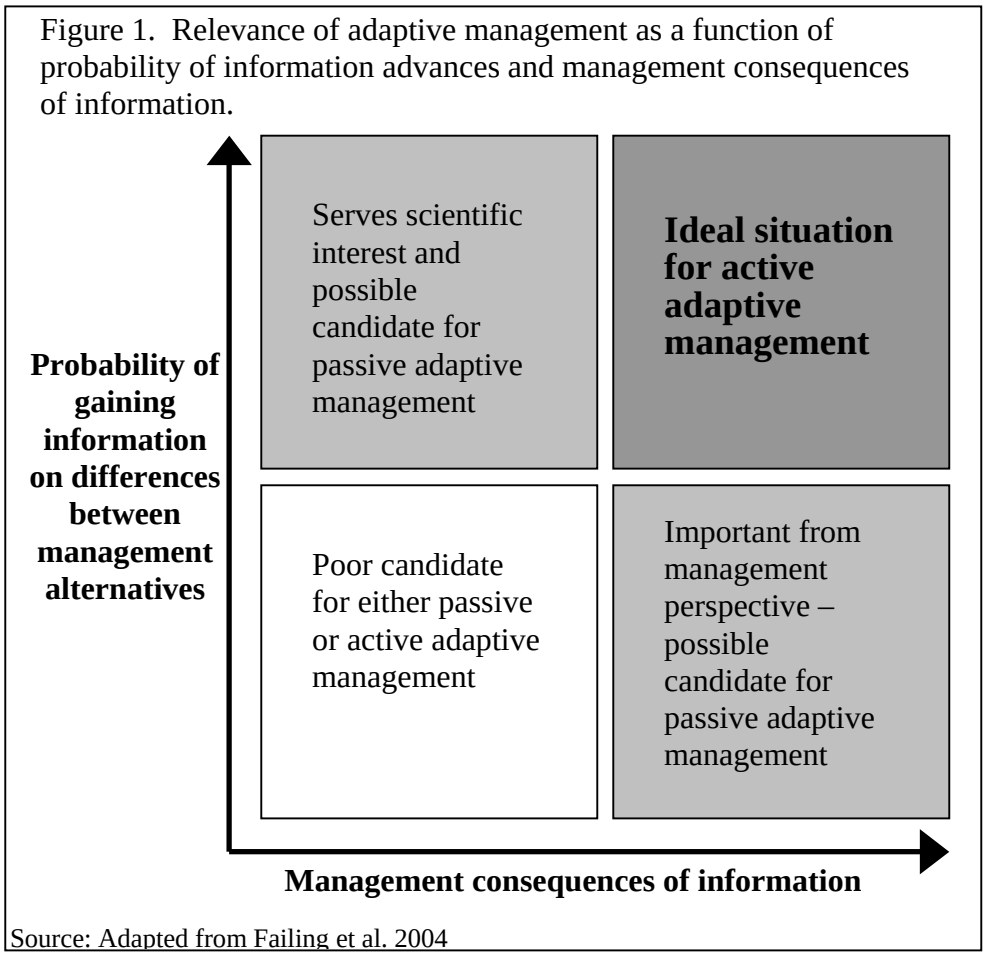

Figure 1. Relevance of adaptive management as a function of probability of information advances and management consequences of information.

Source: Adapted from Failing et al. 2004

Basically, if an experiment with multiple alternatives has a high probability of differentiating between the effectiveness of the alternatives and if the management consequences of those differences are high, then active adaptive management would be effective (upper right box). If probability is high, but the consequences are low, there is a risk of conducting an experiment that may have scientific interest but has little decision-making relevance (upper left box). If the consequences are high, but an effective experiment that has a high probability of showing differences between the alternatives cannot be designed, then an experimental approach would do little good to help define the optimal alternative (bottom right box) (Failing et al. 2004). In these two cases, a passive adaptive management approach could be useful. Conversely, if both the probability of detecting differences between management alternatives is low as are the management consequence of the information, then the expense involved in implementing either an active or passive adaptive management approach is likely not warranted (bottom left box).

Defining the alternatives to be implemented can be one of the most difficult and contentious aspects of an adaptive management approach. For this reason, it is important to develop the model and select alternatives in a transparent manner, including stakeholder involvement when possible, as discussed further in Section 6.

Define Indicators and Develop Monitoring Program.

When people think of adaptive management, the first thing that oftentimes comes to mind is monitoring. Yet, too often the decision is made to conduct monitoring without giving due

consideration and thoughtful evaluation to what it is that should be monitored and how it should be done. This can result in monitoring that collects unnecessary data and ultimately has little management relevance, as it fails to answer the pertinent questions (MacDonald et al. 1991). Thus, the selection of appropriate indicators in establishing a monitoring program is a critical step that is frequently glossed over.

The fundamental question of developing a monitoring program is - what is the desired environmental or biological response or change, and how can that be measured (Harris et al. 2005)? The first part of that question speaks to the goals and objectives, which was already discussed above, but the second part of the question speaks to identifying meaningful, measurable indicators that can provide the information as to whether the management objectives are resulting in the desired response. Holling (1978) stated that one of the first steps in any adaptive management approach is the development of indicators that respond to the issues for which there is uncertainty that is being addressed. Although the selection of indicators is generally recognized as a critical step, there is ironically not an extensive literature base on *how* to choose monitoring indicators.

Perhaps the most comprehensive work on evaluating and selecting indicators for a monitoring program was developed by the U.S. Environmental Protection Agency (USEPA) as part of their Environmental Monitoring and Assessment Program (Jackson et al. 2000). The following discussion summarizes some of the key findings of the USEPA document.

The USEPA outlines fifteen guidelines for the selection of monitoring indicators for environmental issues. The guidelines are grouped into four primary phases: Conceptual Relevance, Feasibility of Implementation, Response Variability, and Interpretation and Utility.

Phase 1: Conceptual Relevance

In order to be a valid indicator in a given situation, it must provide information that addresses the issues of the monitoring program as a whole. In other words, it must be relevant to the question at hand and should be directly applicable to management decisions.

Guideline 1: Relevance to Assessment

Before an indicator can be considered, it must be demonstrable that the indicator is appropriately linked to the management question and capable of providing information relevant to decision-making.

Guideline 2: Relevance to Ecological Function

The indicator must be meaningfully linked to the biological or physical function so that changes in the indicator can be attributed to changes in the ecological function of concern.

Phase 2: Feasibility of Implementation

It is important that selected indicators are feasible and practical given the resource constraints of a given project. The methods, logistics, costs, and other issues of implementation should be evaluated prior to selecting an indicator for a monitoring program.

Guideline 3: Data Collection Methods
The methods for data collection should be well described and standard methods that have been previously demonstrated as effective should be used, if possible, before implementing untested approaches. However, it is important to not just select indicators because they have been used in the past, they must still meet the purpose for which the data is collected (MacDonald et al. 1991).

Guideline 4: Logistics
The logistical requirements of monitoring an indicator must be evaluated to ensure that adequate resources are available to implement monitoring of the indicator. Logistical considerations include field personnel, vehicles, training, travel, sampling instruments, sample transport, analytical equipment, and laboratory costs. The time it takes to conduct fieldwork, analyze the results, and prepare reports should also be considered.

Guideline 5: Information Management
Some indicators produce more data than others and can require substantial resources for management. The requirement of the indicator for data processing, storage, retrieval, and documentation should be considered in indicator selection. The protocols for data compilation and analysis must be made explicit, as turnover on long-term monitoring projects is a key issue and new staff must be able to effectively work with the collected data (Salafsky et al. 2001).

Guideline 6: Quality Assurance
In order to facilitate accurate, meaningful interpretation of monitoring results, it is necessary to establish a quality assurance plan before selecting an indicator to ensure that adequate safeguards are in place so that monitoring of the indicator serves the intended purpose. The approach to ensuring quality should ultimately being incorporated into the overall monitoring plan.

Guideline 7: Monetary Costs
In almost all monitoring programs, cost is a major limiting factor. Thus, it is critical to consider all implementation costs before selecting an indicator. It is also important to consider efficiencies if there are situations in which data for multiple indicators can be collected simultaneously.

Phase 3: Response Variability
One of the most important steps in selecting indicators is the evaluation of the indicators ability to distinguish between extraneous factors and actual environmental change due to resource management strategies. Variability that can obscure changes due to management strategies can be introduced by measurement error and by natural variability. An effective indicator must be able to account for these and still provide information on the environmental response to the management strategies to be monitored.

Guideline 8: Estimation of Measurement Error
Different indicators can be more prone to errors based on collecting, transporting, and analyzing the data generated. These types of errors can impact the meaning of the data.

Before selecting an indicator, an estimation of the variability introduced by human and instrument performance should be made.

Guideline 9: Temporal Variability – Within the Field Season
For most monitoring programs, data cannot be collected at all sites simultaneously. Data is usually collected over days, weeks, and even months and then summarized as a single field season. Thus, there is the potential for variability based upon when during the sampling season a measurement is taken. The indicator's susceptibility to variability due to temporal differences in collection should be considered prior to indicator selection.

Guideline 10: Temporal Variability – Across Years
Measurements for an indicator can change across years even when the overall environmental condition is relatively stable. These changes can be due to such factors as weather, succession, population, or other natural inter-annual variations. To be effective, an indicator should be able to account for these temporal variations so that changes due to natural variability can be discerned from changes resulting from the implemented management strategy (PAMRS 2004). To determine an indicators natural variability, monitoring must proceed for several years at sites known to have remained in the same general ecological condition. This type of variability provides more reason for selecting previously used indicators, as some of this work related to natural variability may have already been conducted.

Guideline 11: Spatial Variability
When considering the use of an indicator, it is important to develop spatial monitoring regions that are truly similar for the environmental condition to be monitored. Grouping dissimilar areas into single monitoring units can obscure differences in environmental response to the management strategies being tested. This may result in differing monitoring units for different indicators, which is why it is important to consider this factor as indicators are being selected.

Guideline 12: Discriminatory Ability
An effective indicator should be able to discriminate between extraneous differences between responses among sites so that the true environmental response can be signaled by the indicator data. The trends in data from one site to another will not likely mirror each other, but a robust indicator provides enough information to discriminate between the site-specific differences to reveal the response trends caused by the resource management strategy being studied.

Phase 4: Interpretation and Utility
This last phase of indicator selection begins to delve more into how the results of the indicator are to be used. An effective indicator produces information that is clearly understood by scientists, policy makers, and the public.

Guideline 13: Data Quality Objectives
In considering indicators, it should be evaluated how sample size, monitoring duration, and other variables affect the precision and confidence levels of the results. As one of the goals in selecting indicators is to do so in the most cost-effective manner, it is important not to spend effort achieving more precision than is needed, but also to ensure that the data is robust enough to obtain the answers to the management questions.

Guideline 14: Assessment Thresholds
To the extent possible, it is useful to choose indicators that have established threshold values or ranges that help delineate acceptable from unacceptable conditions. For example, water quality parameters are useful indicators, as there are state standards for water quality.

Guideline 15: Linkage to Management Action
The most important consideration is that the indicator provides the information that is relevant to making management decisions or evaluating past decisions. An indicator with management relevance should hold at least one of the following characteristics: responsiveness to a specific stressor, link to policy goals, utility in cost-benefit assessments, clearly identifiable limitations of its applications, and easily understood by the public.

The 15 guidelines presented in the USEPA text are important factors that should be assessed in the selection of all indicators as the first step in defining a monitoring program. It may not be necessary to literally work though each of the guidelines for all indicators, but the guidelines provide a basic framework for the types of issues that require consideration.

Once the key indicators to monitor have been identified, the next step is to consider exactly what type of monitoring program is to be developed. Monitoring is a series of identical observations made over time. It is the ongoing, replicated nature of monitoring for the purpose of detecting change that differentiates it from inventories and surveys (MacDonald et al. 1991). Monitoring takes place over years or decades, whereas inventories and surveys are designed to be a "snap shot" of current conditions. For the purposes of adaptive management, how conditions change over time is the key question, which is the reason that monitoring is such an important aspect of adaptive management.

There are various types of monitoring, which are primarily defined based upon the purpose for which the monitoring is conducted. For the purposes of adaptive management, the most important types of monitoring are baseline, implementation, validation, and effectiveness, as described below (MacDonald et al. 1991).

Baseline monitoring is designed to characterize existing conditions that include consideration of natural variability over time. Therefore, baseline monitoring does not take place in a single year, but is conducted at regular intervals over time to help in defining natural variability. It is important to establish this baseline, as once management strategies are implemented it is crucial to be able to assess what changes in conditions are due to the management strategy and what changes fall within the range of expected natural variability.

Implementation or Compliance monitoring evaluates whether the management strategies were actually carried out as planned. For example, if a management strategy included the adoption of a specific BMP, then the implementation monitoring would evaluate over time, the extent to which the BMP was fully put into practice. Implementation monitoring is administrative in nature and does not look at how environmental conditions change, but rather how well a selected management strategy was executed. This type of monitoring is also frequently referred to as *compliance monitoring.*

Validation monitoring is used to determine whether the cause and effect relationship assumptions used in choosing a management strategy hold true in the real world. This type of monitoring is most commonly used to help in determining whether a conceptual model or a predictive computer model provides an accurate depiction of reality.

Effectiveness Monitoring is used to determine whether the management strategies had the desired effect over time. This usually involves first establishing the existing condition using baseline monitoring, then implementing a management strategy and monitoring to determine whether the environment reacted to the management strategy in the intended way. Effectiveness monitoring is likely the most important of the group as it tells whether the management strategy "worked."

A monitoring plan for an adaptive management program may contain one or all of these types of monitoring depending upon the questions that the monitoring is designed to help answer. However, it is important to note that monitoring itself is not adaptive management. Instead, a well formulated monitoring plan is simply a tool to help educate improved management decisions (PAMRS 2004). A monitoring program is only as effective as its framework for evaluating the results and making management decisions, as discussed in the next section.

Framework for Evaluation of Monitoring Results and Adjustment of Management Strategies

The key component that makes a management strategy adaptive is the establishment of a specific framework for the evaluation of monitoring results and a feedback loop that results in adjustments of management strategies to optimize results based upon the pre-established goals and objectives. This evaluation and adjustment component of adaptive management is what constitutes the learning aspect. Without a specific framework for integrating the knowledge gained through monitoring into management actions, learning will not take place and optimal management strategies will not be achieved (PAMRS 2004).

The manner in which evaluation and adjustment occurs is highly variable, from established thresholds that dictate predefined changes in management strategies, to oversight committees that evaluate monitoring data and negotiate management adjustments in a collaborative forum. Based on the situation, these decision-making strategies or others may be most appropriate. However, what is critical, is that the criteria for decision-making and management adjustment is designed before adaptive management is initiated – during the establishment of goals and objectives. Otherwise, political agendas and public opinion can co-opt the evaluation and adjustment process and remove the objectivity that is paramount to effective adaptive management. Further, there must be commitment by the decision-makers to act upon the results of the monitoring data and make the necessary management changes (PAMRS 2004).

During the evaluation and adjustment phase of adaptive management, it is important to consider the constraints of monitoring results. If a management strategy did not achieve the desired results, it could be for a number of reasons that have different implications for next

steps. It could have been because the original assumptions were wrong, the management strategy was poorly implemented, environmental conditions have changed, monitoring methods were faulty, or some combination of these (Salafsky et al. 2001). Because of this, the evaluation and adjustment phase is not the last step in a linear process, instead adaptive management is cyclical. When management adjustments are made, these other confounding factors must also be considered so that when a second, third, and fourth management adjustment still fails to achieve the desired results, these types of variables can also be evaluated as possible reasons that anticipated results were not achieved.

6. Interested Party Involvement in Adaptive Management

Adaptive management does not necessarily require the participation of interested parties in order to be successful, although most definitions and recommendations for adaptive management frameworks suggest that interested parties be involved throughout the process. Further, the original intent of adaptive management, as presented by Holling (1978), was to involve interested parties in a collaborative management framework. The main reason behind involving interested parties in adaptive management is to arrive at decisions that best achieve resource management goals and to reach decisions that experience increased public support (Shindler and Cheek 1999).

However, it can be difficult to involve interested parties in the formulation of an adaptive management framework. Many interested parties may be concerned with the apparent ambiguities of an adaptive approach or with the potential threats to the existing way of doing business. Some parties may also believe that by participating in a collaborative process they are giving up some of their individual control and run the risk of being coerced by other interested parties (Johnson 1999). Further, interested parties have a host of different interests and they may focus narrowly on a single issue, or champion management strategies that may not be scientifically or legally feasible (PAMRS 2004). These types of issues can lead to conflict in the adaptive management process.

Yet differences in opinion between interested parties are not unique to adaptive management and should not be cited as reasons for limiting interested party involvement. Adaptive management does not aim to eliminate differences between interested parties, but it provides an orderly, bounded approach for identifying and working through conflicts (PAMRS 2004, Lee 1999). If stakeholders are willing to negotiate and seek common ground on the goals and objectives of an adaptive management plan, then interested party participation can provide for the collaborative "learning by doing" that is the cornerstone of adaptive management. However, in some situations there may be such intense political conflict that no common ground can be reached. In such instances, an adaptive management strategy is likely not suitable, or at least not a strategy that requires a collaborative working environment among interested parties.

In order to be most effective, interested party involvement should begin in the earliest phases of program development (establishing goals and objectives) and continue throughout the life of the project (Lee 1999, Schindler 1999). Interested parties may be more open to change if they have been involved in the process from its infancy and they have built a sense of ownership over the results. Early involvement can also help to relieve the perception that new conditions are being imposed upon them (Zabel et al. 2002).

Schindler (1999) provides some useful guidance for how best to involve interested parties in adaptive management. Participation of interested parties must be perceived as transparent, balanced, and fair in order to be effective. There is no standard by which to measure these, thus it is important to provide a variety of mechanisms for entities to participate and provide input. The issue is not necessarily whether every single entity is represented throughout, but whether those interested parties that are affected by, or are keenly interested in the outcome are provided ample opportunity to participate.

It is also important for government agencies to have skilled individuals in leadership positions directly involved in interested party participation. It is not enough to hold public meetings where staff "educates" the public on management strategies. It is important that agency staff make the effort to understand the positions of interested parties and to recognize that their issues, which are often social and value-laden are no less valid than positions based upon science. In adaptive management it is critical to balance sociopolitical and scientific considerations in order to effectively engage interested parties (Stankey et al. 2005).

Schindler (1999) suggests that characteristics of successful adaptive management groups include:

1. Participants understand the purpose of the group and its meetings, the expectations of their participation, the expected end product from the group, and they have a sense of ownership over the process;
2. Regular participation by the primary decision-maker;
3. Interested parties believe they are provided with the most current and reliable information; and
4. The group is well organized including: advanced distribution of meeting materials, complex terminology is defined, and questions are answered promptly and directly by the most qualified staff.

It is crucial that government agencies do not involve interested parties simply so that they can make claims of being collaborative. Participation of interested parties must be meaningful and participants must feel confident that their participation actually has an impact on the decisions to be made. Including interested party input in decision-making builds the public trust and can ultimately lead to greater public acceptance of agency policies (Schindler 1999).

Interested party involvement should be well planned out before the adaptive management process begins. There should be explicit answers to key questions such as:

- How will decisions be made?
- What do we hope to accomplish with the public?
- What does the public need to know to participate effectively?
- Who are the key interested parties for this issue?

In answering this last question, it is important to consider the types of representatives that are used. Oftentimes collaborative planning processes like adaptive management tend to involve policy type representatives from interested parties. Yet, since adaptive management of natural resources is intrinsically science-based, it is important to also involve technical representatives in the adaptive management process. This is especially important in setting objectives for the desired environmental condition, evaluating modeling and monitoring results, and deciding upon adjustments to management strategies (PAMRS 2004). It is also useful to include peer review by technical experts that are not directly involved in the adaptive management process to obtain an objective review of the information (65 Federal Register 35242-35257).

7. Why Adaptive Management Has Not Reached Its Potential

In the literature, it is generally agreed upon that while adaptive management has been incredibly influential as a concept to improve management based upon uncertainty, it has not been fully implemented in most cases and has fallen short of its potential (Stankey et al. 2005, Lee 1999). One of the problems in assessing the effectiveness of adaptive management to date, however, is that it requires a long timeframe to evaluate. The concept of adaptive management has only been around since the late 1970s and did not gain substantial acceptance until the 1990s. The timeframes for monitoring and ecosystem response are typically long; therefore, it is too early to definitively know what effects adaptive management strategies have had on the environment (Lee 1999).

It is clear, however, that there are a number of sociopolitical constraints that have hindered the implementation of adaptive management. One of the main constraints is that adaptive management is a fairly involved process that is generally best suited for large-scale ecosystem level projects. This usually also equates to adaptive management either being led or guided by a government agency. Government agencies can be substantially confined by their legal mandates and perceived political constraints (Doremus 2001, Gunderson 1999). This has made it difficult for agencies to incorporate the flexibility that a truly adaptive management process requires.

Similarly, both government agencies and interested parties may be unwilling to compromise during the formulation of goals and objectives, alternatives, or the adjustment of management strategy phases (Johnson 1999). As discussed in Section 6, for adaptive management to be effective, interested parties must be able to reach some common ground on these aspects of adaptive management. If some parties are completely unwilling to seek a mutually agreeable solution on a given subject, the conflict can become an impassible barrier that obstructs adaptive management.

Government agencies and interested parties can also be unwilling to accept the short-term risk of implementing management strategies under substantial uncertainty (Gray 2000). At its core, adaptive management requires action in the face of uncertainty, and in situations where key parties were not willing to accept uncertainty; adaptive management has not proven effective (Johnson 1999). Yet, the literature suggests that the answer is certainly not to limit involvement by interested parties, as inadequate stakeholder involvement is also cited as one of the key reasons why adaptive management has not met its full potential (Stankey et al. 2005).

The timescale at which adaptive management operates also makes it difficult to implement for government agencies. In order to define goals and objectives, develop management alternatives, implement them, monitor, evaluate, and adjust management strategies, government agencies need to commit to the process for decades. It can be difficult to sell the benefits of this long-term commitment to executive management and interested parties, especially given the likelihood that government administrations and priorities will inevitably change over time (Johnson 1999).

The costs of implementing adaptive management have deterred successful implementation. There can be substantial direct and indirect costs associated with developing conceptual or computer models, collecting and analyzing data, fostering a collaborative planning process, and continually adjusting management strategies (Walters 1997). In particular, the literature suggests that the costs of designing and implementing a long-term monitoring program have been one of the primary factors that have limited adaptive management success (Vail and Skaggs 2002). Part of the problem of getting interested government entities to agree to the costs of implementing adaptive management is that much of the costs and associated political burden are borne by current decision-makers, interested parties, and public, while, due to the long-term nature of adaptive management, the full benefits will likely not be realized for decades (Stankey et al. 2005). In addition, since adaptive management entails uncertainty related to how resources will ultimately be managed, there is also uncertainty with how much money management will ultimately cost. This fiscal uncertainty can be difficult for agencies to implement in an era when government accountability and fiscal responsibility are strongly supported (PAMRS 2004).

Further, even when the monitoring data has been adequately collected, there is often insufficient understanding and tools to analyze, understand, and appropriately adjust management strategies (Zabel et al. 2002, Vail and Skaggs 2002). Because adaptive management is used in situations of uncertainty, even when there is more information collected through monitoring, the additional data may not be sufficient to make it clear how or why the environment responded in the way it did. In such situations, it is not possible to know how management strategies should be adjusted to better meet goals and objectives.

The popularity in the concept of adaptive management has also led some entities to use the term as an empty symbol for better management when in fact they are continuing to operate at status quo (Doremus 2001). This has resulted in confusion over the definition of adaptive management and skepticism in regards to its utility. This problem has also been fueled by the frequent perception of government agencies that they must maintain a pretense of certainty in order to maintain public credibility. If a government agency acknowledges that it does not

know exactly how to manage a resource, it is perceived that constituents will lose faith that the agency can best manage natural resources. Decision-makers need to realize that they will increase an agency's credibility by admitting uncertainty and then actively working on solutions for dealing with and reducing that uncertainty through adaptive management (Walters 1997).

8. Institutional Changes That Could Improve Adaptive Management Implementation

Recognizing the shortcomings of adaptive management implementation to date, the literature offers a handful of suggestions for how institutional changes could help lead to improved adaptive management. Some of the changes include building flexibility into authorities to allow for adaptive management, obtaining a stable funding framework for monitoring and evaluation, ensuring strong management support and entrusting adaptive management programs with highly skilled managers, and creating an atmosphere in which failure and experimentation is accepted.

One of the more difficult obstacles in adaptive management implementation for government agencies is providing the flexibility for trying different management strategies within the current regulatory framework. Entities with strict rules or statutory restrictions may be constrained in their ability to implement the knowledge acquired through monitoring the effects of management strategies (Parma et al. 1998, Stankey et al. 2005). For most government agencies, this is a serious issue and it may be necessary to seek expanded authority specifically to provide for adaptive management approaches. For example, for the Comprehensive Everglades Restoration Project, the Army Corps of Engineers specifically asked Congress for the authority to use adaptive management due to the uncertainties associated with the project. The authority mandated Army Corps participation in post construction decision-making (PAMRS 2004). Oftentimes in environmental regulations, construction is seen as the endpoint, and there is no continuing authority for post construction management. This type of extended authority would greatly improve the ability to adapt to evolving public values, changed environmental conditions, and new scientific information. Yet in making any changes to authority, it is important that the changes allow for flexibility, while maintaining constraints and oversight to ensure that adequate protective measures are in fact taken (Doremus 2001).

Similarly, it is important for government agencies, either through policy or through requesting changes in authority, to make monitoring a consistent part of project expectations and to provide the funding to carry out monitoring long-term. Although virtually all agencies have policies that suggest that monitoring be a part of projects they conduct and authorize, few agencies consistently carry out monitoring long term. For adaptive management to be successful, long-term monitoring must become the norm. One of the reasons that monitoring has been difficult to require regularly is that it can be expensive. One potential solution is to ask state and federal legislatures to provide funding specifically for project monitoring. A dedicated, legislatively mandated funding source for monitoring would help to ensure that

efforts are continued long term. Such funding sources are beginning to occur in a piecemeal fashion, but what is needed is a more comprehensive, government funded monitoring program. This would include funding for both government and non-government project monitoring. Thus, some of the onus for monitoring would be taken off of the applicant and put on the government. However, the majority of the monitoring burden should still be borne by private develop interests, as it is not equitable to use government funds to fully subsidize the monitoring responsibility for private interests. Yet, having a portion of the cost covered by public funding would help ensure that monitoring actually occurs and is conducted in a high quality, consistent manner.

For adaptive management to work for a governmental agency, it requires cross-sectoral support with interested parties, but also support within the agency. It especially requires strong commitment from top managers (Salafsky et el. 2001). The literature suggests that adaptive management programs that have been most effective to date have been led by a manager that is a passionate, visionary leader who serves as a change agent within the organization. It is important for government agencies to recognize this need and entrust the lead to a manager that is a respected activist, integrator, and facilitator and instill them with enough decision-making authority to affect change. Without such a presence, adaptive management efforts tend to slowly unravel or stagnate (Stankey et al. 2005).

It is also important that the agency works though the leader of the program to become an "adaptive institution." An adaptive institution is one in which there is an open atmosphere that is "participatory and inclusive, integrative, collaborative, risk tolerant, and flexible" (Stankey et al. 2005). Managers need to encourage their staff to find innovative solutions and make sure they know that it is okay if optimal results are not achieved. It needs to be stressed that evaluating and learning from the results of attempts to innovate is what is most important. Staff need to feel confident that they will not be blamed or reproved if success is not achieved on the first try. Traditionally, failure is seen as something to be avoided at all costs, which precludes the implementation of solutions that seem risky. Further, when efforts do fail, entities often are quick to move past or downplay the result instead of openly evaluating to better inform and improve future management (Salafsky et al. 2001). This institutional ideology that occasional failure is a necessary component of learning is critical to effective implementation of adaptive management.

9. Adaptive Management Use in Habitat Conservation Planning

In the handbook for conservation planning, USFWS and NOAA Fisheries promote the use of adaptive management in the formulation of HCPs. The handbook states that: "The primary reason for using adaptive management in HCPs is to allow for changes in the mitigation strategies that may be necessary to reach the long-term goal (or biological objectives) of the HCP, and to ensure the likelihood of survival and recovery of the species in the wild" (USFWS and NOAA Fisheries 1996). The Services recognize that when formulating a management plan for anywhere from five to fifty years, there will inevitably be uncertainties that cannot be

addressed. The Services suggest that even with limited information at the outset, approval of a long-term plan can be justified when it implements cautious, incremental action within a framework providing rigorous monitoring and a process for evaluating and revising management actions (Doremus 2001).

The Services further solidified their commitment to adaptive management in conservation planning in 2000, when they issued an addendum to the 1996 handbook, commonly referred to as the five points policy. One of the five points is adaptive management and the addendum provides more explicit detail about the use of adaptive management in HCPs. The Services outline a somewhat unique definition of adaptive management for the purposes of conservation planning. Adaptive management is defined as: "… a method for examining alternative strategies for meeting measurable biological goals and objectives, and then, if necessary, adjusting future conservation management action according to what is learned" (65 Federal Register 35242-35257). This definition is somewhat more broad than that used by some adaptive management practitioners. The reason for this broader definition is that for Endangered Species Act planning, the Services state that there is a need to be cautious with the application of adaptive management, since a cavalier, experimental approach could present serious risks to species persistence. Therefore, an active adaptive management approach may pose too much of a serious risk to listed species and the Services suggest that more of a passive adaptive management strategy is appropriate for HCPs. Yet even with constraints due to species risks, the Services believe that it is important to use adaptive management when necessary to provide the flexibility to change implementation strategies after permit issuance.

Adaptive management is to be used in HCPs when there are significant data gaps that would otherwise preclude the services from approving an HCP. The adaptive management program must be tied to the biological goals and objectives of the plan and be based on scientific information. Adaptive management cannot be used as a catchall for all uncertainties or issues that could not be resolved during the negotiation of the HCP. It is only appropriate when there is inadequate scientific information regarding the biological or habitat needs of a species covered by the HCP and it is believed that implementation of actions, monitoring, and evaluation could help to alleviate some of that uncertainty. The Services note that the types of data gaps that may warrant an adaptive approach include:

> …a significant lack of specific information about the ecology of the species or its habitat (e.g., food preferences, relative importance of predators, territory size), uncertainty in the effectiveness of habitat or species management techniques, or lack of knowledge on the degree of potential effects of the activity on the species covered in the incidental take permit (65 Federal Register 35242-35257).

The Services propose that there is oftentimes a direct relationship between the level of uncertainty related to a species and the level of risk that the HCP could pose to the species recovery. Therefore, it may be appropriate for management strategies with uncertainty to be relatively cautious initially and potentially adjust management to be more liberal after monitoring results reveal the effects of the strategy.

Some have suggested that the use of adaptive management is not compatible with the "no surprises" assurances that were incorporated into the ESA rules in 1998. Under the no surprises assurances, a holder of an incidental take permit cannot be required to enact additional mitigation measures or provide financial compensation for unforeseen circumstances that arise in relation to a covered species or its habitat after the permit is issued. Yet the Services note that this only applies to unforeseen circumstances. If an HCP clearly identifies data gaps and uncertainties and provides a structured framework for how these uncertainties will be managed, monitored, and evaluated, then it is not an unforeseen circumstance and there can be changes to the management strategies over the course of HCP implementation. It is critical to provide certainty to an HCP proponent that the adaptive management plan clearly sets the sideboards for what types of management strategies can and cannot be considered through adaptive management. The Services cannot require an incidental take permit holder to implement actions that are outside of the sideboards of the HCP and the agreed upon adaptive management program. Therefore, use of adaptive management does not affect the protections provided to an HCP proponent through the no surprises assurances.

It is important to note, however, that the no surprises assurances do not apply to changed circumstances. Changed circumstances include such things as fires, floods, droughts, and the addition of new species to the ESA list that are not covered in the HCP. The Services can require an HCP proponent to incorporate mitigation measures for changed circumstances. For this reason, an HCP proponent should explicitly address these types of changed circumstances and how they will be handled in the HCP. If there is uncertainty as to how changed circumstances should be handled, these should also be addressed in the adaptive management program. By doing so, the HCP proponent can maintain some level of certainty over what would be expected of them in the event of changed circumstances.

In addition to providing certainty of what is to be expected, a thorough adaptive management plan could also result in cost savings over the course of HCP implementation. Oftentimes, when there is uncertainty, the precautionary principal is used to implement management strategies that are deemed conservative enough to ensure that the species and its habitat will not be jeopardized. Yet, with a comprehensive monitoring and adaptive management program it is possible that monitoring results will show that management strategies are performing better than anticipated and it may be possible to adjust to less expensive strategies that still meet the goals and objectives of the HCP. The Plum Creek Timber Company Native Fish Habitat Conservation Plan is an example of an HCP that includes such provisions (Doremus 2001).

One of the potential shortcomings in the conservation planning process is that there are no specific provisions for the participation of interested parties. The Services strongly encourage the inclusion of interested parties in the development of an HCP, but it is largely at the discretion of the applicant. This can be especially challenging for the development and implementation of an adaptive management program for an HCP. In the five points policy, the Services recommend that interested parties be involved throughout the planning process, especially in adaptive management development. The Services suggest the use of oversight committees made up of representatives from interested parties to periodically review the monitoring and adaptive management programs and to ensure that the terms and conditions of

the HCP are properly implemented. This oversight committee can be the body responsible for evaluating monitoring results and adjusting management strategies, as necessary. As discussed in the previous section, participation of interested parties can bolster acceptance and confidence in the HCP.

10. Preliminary Ideas for Adaptive Management Use in the Hydraulic Project Approval Habitat Conservation Planning Process

WDFW is only in the first year of an expected six-year project to develop and finalize an HCP for the HPA program. Because the project is still very early in its development, it is too soon to formalize a specific adaptive management strategy, as it cannot be predicted at this point what types of uncertainties may arise that would be candidates for adaptive management. However, in order to put the agency in a good position to incorporate adaptive management into the HCP if the need should arise, it is important to start considering how this could be accomplished.

One of the first things that the agency is doing that will certainly assist with adaptive management is encouraging participation by interested parties from the outset. The first portion of work that was conducted for the HPA HCP was a needs assessment for public involvement. A contracting team (Jones and Stokes and Caleen Cottingham) was hired to conduct over 40 interviews with key interested parties to get their impressions on the HPA HCP, suggestions for success, and how they would like to participate in the planning process. Through this needs assessment, the contracting team is working with WDFW to create a comprehensive public involvement strategy for the HCP. It is expected that as part of this, there will be a policy advisory committee established, comprised of representatives from key interested parties. This group will review the work produced through the planning process and make recommendations to WDFW as what the HCP should include. In addition, there will likely be technical sub-committees that review best available science related to the activities permitted under the HPA program and work on proposed management strategies for the HCP.

This type of interested party participation is precisely in line with what is recommended for a successful adaptive management process. Once substantial uncertainties are identified during HCP development, the policy advisory group and technical subcommittees can serve as the forums for developing adaptive management goals and objectives, creating alternative management strategies, formulating an implementation approach, and deciding upon a framework for evaluating monitoring results and adjusting management strategies. Through using this type of collaborative approach, WDFW should experience some of the benefits of interested party participation such as increased public support and trust.

During this first year of the project, WDFW is doing other work that eventually will benefit an adaptive management approach. WDFW has hired another contracting team (Anchor Environmental, Jones and Stokes, and R2 Resource Consultants) to conduct literature reviews and prepare white papers on the possible impacts of HPA activities on potentially covered

species, possible mitigation measures, and data gaps. By compiling the data gaps at the outset of project planning, WDFW hopes to identify uncertainties as early in the process as possible. Those that could be easily answered with additional studies may be addressed during the planning process. Yet for those uncertainties that cannot be readily addressed, they will become candidates for an adaptive management approach.

The Anchor Team also conducted interviews with WDFW biologists that implement the HPA authority. WDFW field biologists were asked about the types of activities permitted by HPA for which there is high level of uncertainty that may benefit from adaptive management. Some of the activities the biologists identified as top priorities included fish passage on steep slopes, culvert replacement methods, innovative bank protection systems, engineered habitat improvements, overwater structures, pile driving, and vegetation restoration. The information from the field biologists, along with the data gaps identified in the white papers, will be used to further clarify issues that may be suitable for adaptive management. This early identification of these significant uncertainties should help to position the agency to develop a comprehensive adaptive management program for the HCP.

WDFW is also conducting work to evaluate how other HCP projects have utilized adaptive management. A contractor (Parametrix) has been hired to conduct a review of about 20 HCPs from around the nation that have similar characteristics to the two HCPs that WDFW is pursuing. One of the components that the contractor will be assessing is how these HCPs utilized adaptive management. WDFW wishes to learn from what others have done and use strategies that have already been used and proven effective. This early evaluation of other HCPs should help focus WDFW's formulation of an adaptive management plan for the HPA HCP.

Based on the information WDFW has conducted during the first year of the project and the information reviewed in preparation of this report, Table 1 includes a broad outline of how the adaptive management framework for the HPA HCP may be structured.

Table 1. General Outline for the HPA HCP Adaptive Management Framework.

I. Development of management goals and objectives.
   a. Management goals and objectives would be defined by the Policy Advisory Committee and/or technical sub-committees established during HCP development.
   b. Preliminary goals will be developed by WDFW and then presented to the advisory committees. General goals may include:
      i. Ensure that activities permitted under the HPA authority are conducted in a manner that ensures protection of listed and at risk species and are fully compliant with the ESA.
      ii. Streamline the permitting process for HPA applicants by providing long-term ESA compliance assurances for covered activities.
      iii. Fully assess the negative impacts on listed and sensitive species and their habitats resulting from activities permitted under the HPA authority utilizing the best available scientific information.
      iv. Create an HCP that not only mitigates for potential adverse impacts on listed and sensitive species but that contributes to species recovery, to the extent possible.

Table 1. General Outline for the HPA HCP Adaptive Management Framework.

v. Develop standards in the HCP and WAC to ensure that the HPA authority is implemented consistently statewide.

II. Formulation of management alternatives.
   a. Throughout the next three to four years, WDFW will be conducting literature reviews, field studies, and other research to help define management alternatives for HPA activities. Through this work, WDFW and the Policy Advisory Committee will establish management alternatives to be carried forward in the HCP.
   b. Alternatives will be science-based. WDFW science staff and other technical experts will review all management alternatives to inform the Policy Advisory Committee of potential conflicts and uncertainties associated with each management alternative. These will form the basis of the issues to be studied through adaptive management. HPA activities identified to date that are priorities for an adaptive management approach include:
      i. Fish passage on steep slopes.
      ii. Culvert replacement methods.
      iii. Innovative bank protection systems.
      iv. Engineered habitat improvement structures.
      v. Overwater structures.
      vi. Pile driving.
      vii. Vegetation replanting/restoration.

III. Selection of indicators to be measured and development of the monitoring program.
   a. Identify key uncertainties with management assumptions and review possible indicators that are relevant to the assessment of changes associated with implementing a given management alternative.
      i. Articulate the conceptual models and assumptions related to the cause and effect linkages between management alternatives and the desired outcomes.
      ii. Evaluate the costs, data collection methods, and logistics to help ensure an efficient monitoring program.
      iii. Evaluate the literature regarding the vulnerability of the indicator to measurement error, temporal and spatial variability, and each indicator's ability to reveal actual differences between sites due to the management alternative implemented.
      iv. Select a suite of monitoring indicators that address all key management uncertainties, goals, and objectives.
   b. Define performance standards or thresholds for monitoring. This should be done through the Policy Advisory Committee and/or Technical Committee's. These standards and thresholds will define success for the management alternatives and also suggest at what points changes in management strategies may be warranted.
   c. Fully define monitoring methods, timelines, and responsible parties.
   d. Describe how monitoring data will be reported and evaluated for quality.

IV. Framework for Evaluation of Monitoring Results and Adjustment of Management Strategies
   a. It is anticipated that the HPA HCP adaptive management program will involve a collaborative review committee type structure. Perhaps the Policy Advisory Committee established for the HCP will be used to review monitoring results and suggest management adjustments.

Table 1. General Outline for the HPA HCP Adaptive Management Framework.

b. The framework for the committee must establish a set protocol for how monitoring results are to be interpreted and reported to the committee.
c. The framework must establish how progress toward performance standards will be assessed. Important questions to consider include:
    i. Was the performance measure a feasible metric that gave an accurate measurement of the standard?
    ii. Do results show change along a predicted ecological trajectory toward the goals and objectives? If not, are there factors constraining or impacting the system?
    iii. Is the system functioning well and should performance standards be changed?
    iv. Are there any design changes needed for future monitoring?
d. The framework must identify the types of recommendations the committee may suggest based on the monitoring results. For example:
    i. Redefine the problem (e.g., alter geographic scope), restate goals, or alter evaluation criteria (e.g., may be using inappropriate indicators to measure progress toward goals).
    ii. Use new understanding to inform management strategy changes (e.g., there may be a need to consider a change to the HCP management strategies for a given activity type).
    iii. Redefine timelines (e.g., monitoring results may be inconclusive and additional study may be needed to clarify results).
e. The HCP must place explicit sideboards on the types of changes to management strategies that can be considered based on monitoring results. The adaptive management committee must work within these sideboards for all management recommendations.

One challenge to the use of adaptive management for the HPA HCP will be the regulatory nature of the program. The HPA program is bounded by explicit statutes and rules, which may make it difficult to incorporate the type of flexibility that an adaptive management approach requires. While it can be difficult to change statutes, it is possible for WDFW to work with stakeholders to change the rules (Washington Administrative Code (WAC) 220-110) for the HPA program. It may be possible to incorporate specific rules that provide for an adaptive management strategy, similar to what the Army Corps was able to do for the Everglades restoration project described previously. However, since the HPA is a regulatory authority, an adaptive approach will need carefully developed sideboards so that applicants know exactly what is expected of them and so that WDFW is applying the HPA authority consistently and fairly. Incorporating flexibility will likely be the most difficult challenge for using adaptive management for the HPA authority.

This paper marks only the first step in outlining how adaptive management may be used for the HPA HCP. As additional work is conducted and management strategies are formulated for the HCP, this paper will be continually revisited and expanded upon as significant uncertainties are identified an adaptive management program begins to take shape for the HCP.

11. Bibliography

Doremus, H. 2001. Adaptive management, the Endangered Species Act, and the institutional challenges of "new age" environmental protection. Washburn Law Journal 41(1):50-89.

Failing, L., G. Horn, and P. Higgins. 2004. Using expert judgment and stakeholder values to evaluate adaptive management options. Ecology and Society 9(1):13.

Federal Register. 2000. Availability of a final addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process – Five Points Policy. June 1, 2000. 65(106):35242-35257.

Gray, A.N. 2000. Adaptive ecosystem management in the Pacific Northwest: a case study from coastal Oregon. Conservation Ecology 4(2):6.

Gunderson, L. 1999. Resilience, flexibility, and adaptive management – antidotes for spurious certitude? Conservation Ecology 3(1):7.

Harris, R.R., C.M. Olson, S.D. Kocher, J.M. Gerstein, W. Stockard, and W.E. Weaver. 2005. Procedures for monitoring the implementation and effectiveness of fisheries habitat restoration projects. Center of Forestry, University of California, Berkeley. 24pp.

Holling, C.S. (ed.). 1978. Adaptive environmental assessment and management. International series on applied systems analysis. International Institute for Applied Systems Analysis. Wiley and Sons. 377pp.

Jackson, L.E., J.C. Kurtz, and W.S. Fisher (eds). 2000. Evaluation guidelines for ecological indicators. EPA/620/R-99/005. U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC. 107 p.

Johnson, B.L. 1999. The role of adaptive management as an operational approach for resource management agencies. Conservation Ecology 3(2):8

Lee, K.N. 1999. Appraising adaptive management. Conservation Ecology 3(2):3

MacDonald, L.H., A.W. Smart, and R.C. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. Center for Streamside Studies in Forestry, Fisheries, and Wildlife. University of Washington. 166pp.

Miller, A. 1999. Environmental problem solving psychosocial barriers to adaptive change. Springer. New York. 239pp.

Nelson, M. 2000. The changing face of HCPs – Habitat Conservation Plans. U.S. Fish and Wildlife Service. Arlington, Virginia.

Panel on Adaptive Management for Resource Stewardship (PAMRS). 2004. Adaptive management for water resources project planning. National Research Council. 138pp.

Rogers, K. 1998. Managing science/management partnerships: a challenge of adaptive management. Conservation Ecology 2(2):1.

Salafsky, N., R. Margoluis, and K. Redford. 2001. Adaptive management: a tool for conservation practitioners. World Wildlife Fund, Biodiversity Support Program.

Shindler, B. and K.A. Cheek. 1999. Integrating citizens in adaptive management: a propositional analysis. Conservation Ecology 3(1): 9.

Stankey, G.H., R.N. Clark, and B.T. Bormann. 2005. Adaptive management of natural resources: theory, concepts, and management institutions. General Technical Report PNW-GTR-654. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 73pp.

Vail, L.W. and R.L. Skaggs. 2002. Adaptive management platform for natural resources in the Columbia River Basin. Pacific Northwest National Laboratory. PNNL-13875. Prepared for the U.S. Department of Energy.

Walters, C. 1997. Challenges in adaptive management or riparian coastal ecosystems. Conservation Ecology 1(2):1.

Zabel, C.J., L.M. Roberts, B.S. Mulder, H.B. Stauffer, J.R. Dunk, K. Wolcott, D. Solis, M. Gertsch, B. Woodbridge, A. Wright, G. Goldsmith, and C. Keckler. 2002. A collaborative approach in adaptive management at a large-landscape scale. *In* J.M. Scott, P.J. Heglund, M.L. Morrison, J.B. Haufler, M.G. Raphael, W.A. Wall, and F.B. Samson (eds.). Prediction species occurrences: issues of scale and accuracy. Island Press. Covello, CA. pp. 241-253.